Learning to Read: an Unnatural Act

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Consider the child of six on the threshold of elementary school. The first thing one notices is his size: he stands only 45 inches (115 cm.), and he weighs only 45 pounds (20 kg.). But atop that small body rests a large head: its diameter of 53 cm. is nearly 95 percent of its adult size (Tanner 1978), and within it resides a brain containing a remarkable collection of skills and abilities.

The six-year-old's sight is as good as the adult's (Amigo 1972), and his hearing is nearly so (Elliott and Katz 1980).

The child has an excellent memory (Mandler, in press), and his learning ability is remarkable. Even a conservative estimate of the size of his vocabulary will show that he must have learned, on average, more than four new words every day since his first birthday (Carey 1978). He has already learned to speak and understand his native language with remarkable fluency.

The average American six-year-old can already produce and recognize more than a dozen vowels and nearly 30 consonants of English. He can produce and understand literally thousands of different words, and he can comprehend virtually any sentence that one can form with those words. To be sure, his language acquisition is not complete. Over the next decade he may have to smoothe out some rough spots in his phonology (Templin 1953), his vocabulary will grow by many more thousands of words (Oldfield 1963), and he must capture a few syntactic niceties which still escape him (Chomsky 1969). But his mastery of English would be the envy of any college graduate learning English as a second language.

Yet for all his cognitive and linguistic talents, the child has one peculiar linguistic shortcoming: he cannot read a word. Indeed, that is one of the primary reasons why we now send him to elementary school. His teacher

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now gives him the best instruction she can, every school day for the next nine months. At the end of the school year, we examine his skills again, using a standardized test battery, like the Metropolitan Achievement Tests. How does he do?

The 1970 Metropolitan Achievement Tests contain three reading subtests. The first of these, called Word Knowledge, contains 35 items in which the child is asked to select the one printed word of four which matches an accompanying drawing. All of the words in their spoken form must be familiar to every child of six; and most of them — like *pants* and *nose* and *train* and *clown* — are monosyllabic. Yet the average child — the child who scores at the 50th percentile on the test's norms — gets no more than two out of three correct. Moreover, fully a fourth of the children get less than half (17/35), and we must remember that they could get a fourth right by guessing, even if they could not read a word.

The second subtest, called Word Discrimination, is even more straightforward. The tester reads a word aloud, and the child is asked to find that word among four alternatives. Again, all the words are short and familiar (though now the distractors are more similar to the answer than in the first test), and the average child gets only 27 out of 40 right, a quarter get about half, and a tenth perform almost at chance.

The third subtest, called Reading, has two parts. One asks the child to choose the one sentence (of three) which goes with a picture; the other asks the child to read brief passages and then answer questions about them. The items are not at all demanding, and the child can get one of three right by guessing. Yet the average child gets less than half of the items right, and a fourth of the children perform at chance or worse.

The point of this grim recitation is not to find fault with our children, their teachers, or their methods, but rather to illustrate a point which has seemed obvious to most linguists, but less so to some reading experts (e.g., Goodman and Goodman 1979; F. Smith 1976), namely, that children do not easily learn to read.

To be sure, there are exceptions; some children learn to read with little apparent difficulty. By the end of the first grade (or even before) some children can read anything put in their hands (Durkin 1966). But the achievement test results show that the statistically average child, normally endowed and normally taught, learns to read only with considerable difficulty. He does not learn to read naturally. That is, despite his evident facility at learning, and despite having previously mastered what would seem to be the hardest part of reading (i.e., learning an unknown language), children almost never learn to read without instruction, and even when given explicit, devoted,

daily instruction, the average child learns to read very slowly, and with great difficulty. To try to see why, let us look at the process of learning to read.

The First Stage: Paired-associate Learning

Reading begins naturally enough as paired-associate learning. The child forms an association between a printed word and its spoken form in the same way that a college sophomore learns an association between two nonsense syllables in a verbal learning laboratory.

By this we do not mean to suggest that the child begins to read only when confronted with a set of flash cards or a basal reading list. Clearly, many children learn to read their first words in an apparently spontaneous fashion well before they encounter any reading program. The child will pick up one word from a television commercial, another from a cereal box, still another from a street sign. But what we would claim is that whether the child's first words are learned spontaneously, through drill, or any other form of instruction, they will be acquired as arbitrary associations like those of the paired-associate list in the laboratory.

We also do not intend to suggest that the child gradually acquires these words by rote, by a gradual strengthening of a mental habit connecting the printed word as stimulus with the spoken word as response. It was once thought that all associations were acquired in this fashion, and the paired-associate item was long thought to be a prototypical example (Staats and Staats 1963). But we now know that this was wrong, that the learning of a paired-associate item, far from being the automatic and gradual strengthening of a connection between the total stimulus and the response, is instead a matter of selective learning, a kind of problem solving in which the learner seeks some attribute of the stimulus which will distinguish it from its competitors (Greeno et al. 1978).

The way paired-associate learning seems to go is this: the learner presented with a stimulus-response pair selects some aspect, some attribute, some feature of the stimulus, connects the response to that aspect, attribute, or feature, and stores the association in memory. When he next encounters that aspect, that attribute, that feature, whether in the same stimulus or another which happens to share it, he will produce the associated response. If it happens to be correct, he will retain the hypothesized connection. If it is wrong, he will discard that feature of the stimulus and select another.

We suppose that the child learns to read his first words in the same way. That is, he will associate a familiar spoken word with a selected attribute of the word's printed form, and place it in memory. Thus given *dog*, he may note

that it begins with a *d*, or that it has a circle in the middle, or that it has a tail on one end. When he subsequently encounters (and attends to) the selected attribute, in the same or any other word, he will retrieve the association from memory and read the printed word in front of him as the associated spoken word. But if he fails to note the memorized attribute, he will fail to recognize the word.

The surest evidence for this kind of selectional, paired-associate learning in beginning reading can be found in experimental studies with pre-readers (i.e., kindergarteners) who are asked to learn to read lists of new words. In these studies (e.g. Otto and Pizillo 1970), it has been shown that children learn to read lists of dissimilar words faster than lists of similar words. When the words are dissimilar, it is easier to find cues which will distinguish among them. But the dissimilar lists lead to more misreadings of other words or *overgeneralization errors*. The easily-found cues of the dissimilar list do not work as well to distinguish the learned items from novel words outside the list.

But we are even more persuaded by observational and anecdotal evidence. The selectional assumption seems to us to rationalize several common observations concerning the beginning reader.

For one thing, the selectional hypothesis leads us to expect that the first words will come easily for any child. For the child to master a few words all he needs is some cue to distinguish each of them. He might note that one word is more jagged than the others, or longer, or printed in an unusual font. So it should be an easy matter for any child to acquire a few sight words. For the same reason, we predict that the first words a child learns to read will be those which are most visually distinctive. The regularity of their spelling, their meanings, their length, their complexity, their relevance, should all matter less than their visual distinctiveness. Thus many children will recognize words like *Budweiser* and *Safeway* in their distinctive fonts long before they can read *dog* or *house* or *cookie*.

Most important, the selectional hypothesis helps to explain many of the seemingly bizarre errors made by beginning readers. If the child arbitrarily selects and attends to an arbitrary aspect of the word, then clearly he need not attend to, or even notice, all the letters of the word, or their order. (In fact, he need not attend to any of them.) Thus he might misread as *dog* any word which begins with *d*, or has a circle in the middle, or seems to have a tail at one end. And he might read a word correctly for the wrong reason, as when a child told Frank Smith (1976) that he read the word *Stop* on a stop sign because "It says p-o-t-s."

The selectional hypothesis also offers an explanation for at least some of the inconsistency often noted in beginning readers. Parents and teachers are occasionally puzzled by the fact that the beginning reader will read a word correctly on one occasion and then misread it on the next. On the selectional hypothesis, this should not be unusual; it should happen whenever the reader happens to attend to some aspect of the word other than the one with which it is associated in his memory.

Finally, the selectional hypothesis helps us to understand why the search for the cues by which the child recognizes words has yielded no consistent results to date. A fair amount of research in education has been conducted to discover whether the child uses the first letter or the last, the upper half of a word or the lower, the general configuration, or some other cue in recognizing a word (Tinker 1965, Chapter 3). On the selectional view, it is doubtful that any single cue is used consistently. The child will use any cue he can, and which cue is used in the case of a particular word will be determined as much by the character of the other words in the child's reading vocabulary as by the word itself.

The selectional paired-associate technique, the child's natural strategy for learning arbitrary associations will work well enough for any and every child, in the beginning. That is, we expect that success in learning to read the first few words, even the first few dozen, will largely be independent of the child's later success. So we predict that many children later diagnosed as dyslexic will begin to read quite normally, and we are not surprised that evidently disabled readers can be taught to read a few dozen Chinese characters with relative ease as Rozin, Poritsky, and Sotsky (1971) have shown. But the paired-associate strategem must eventually come to grief.

The problem with the paired-associate approach to the reading problem is that the difficulty of learning to recognize a word must increase with each additional word. When there are only two words to be read, any cue which distinguishes one from the other will suffice. Add a third, and you must not only find a new cue for that item, but you must also replace any cue for the old two which happens to be shared with the new one. With each new word, the difficulty of finding a unique cue to distinguish it will increase, the child will make an ever-increasing number of errors, and his reading will become more and more halting and confused. The child must come to recognize that he has been trying the wrong thing, that his natural strategy will not work.

We do not claim that the end of the first stage will come suddenly, that the child who has mastered (say) 40 words will be totally frustrated by the

41st (though we are willing to bet that this could happen). More likely, the end of the associational stage will come gradually, as the frequency of errors and confusions increases. Moreover, we do not claim that the child must completely discard the associational device for relating the printed word to the spoken, for there are aspects of the orthography which could be mastered in no other way (the fact that *feel* is not spelled *feal* is but one of hundreds of examples). But we do claim that there must be a basic discontinuity in acquisition, when the child who has been treating the written language as if it were a *code* must confront the fact that it is a *cipher.*

The Second Stage: Cryptanalysis

Let us explain the cryptic remark made above. In the language of cryptography (the science of codes; cf. Kahn 1967), the message which is to be encoded is called the *plaintext*, and the coded message is called the *ciphertext*. Most of us are inclined to think of a code as a system of substitution whereby one letter is substituted for another to encode a plaintext into ciphertext, and this is the kind of code used to create the cryptograms in our daily newspapers. But, technically speaking, this is only one of many different kinds of code, and it is in fact called a *cipher* by cryptographers. Cryptographers use the generic term *code* to refer to any system relating ciphertext and plaintext, and within this broad category, they distinguish between ciphers and other codes. The difference between the two is hard to define, but easy to illustrate.

In a code, the words and phrases of the plaintext are replaced by one or more symbols of code, but there is no relation between the subunits of the code symbols and the subunits of the plaintext. There is nothing in *007* which corresponds to the *m* in *James* or the *b* in *Bond*. In a cipher, on the other hand, there is a systematic relationship between ciphertext and plaintext elements. So *James Bond* might be enciphered into *kbnft cpoe* by replacing each letter in the plaintext by the next letter in the alphabet.

The notion that the written language is a code which the child must learn to decode in order to read is now commonplace. It can be traced, we think, to the writings of the distinguished American linguist, Leonard Bloomfield (1933, 1942), and it has been in popular use since Chall (1967) used the term *code emphasis* to describe one side of The Great Debate (among reading experts) in her classic book of that title. But the notion has served as little more than a label, a metaphor, almost a euphemism, for a certain kind of reading instruction.

We would argue that the metaphor must be taken seriously, that the child who would learn to read *must* learn to decode and in fact, to *decipher.* And we would argue that this fact has important consequences for our conception of reading acquisition.

The cipher which the child must master is far from simple; in fact, it could not be simple, given that English has only 26 letters in which to encipher more than 40 phonemes. Some of the most serious attempts to describe the English orthographic cipher have resulted from the effort to build reading machines for the blind (see Venezky 1967; Cronnell 1971). One such effort, directed by Jonathan Allen of M.I.T., incorporates as many as 577 rules (Hunnicutt, undated). Some of these rules map a single letter onto a single phoneme, like *b* onto /b/. Others map a pair of letters onto one phoneme, as in *th* 〉 /θ/ or *sh* 〉 /š/. A few relate a single letter to a pair of phonemes (like *x* to /ks/), and some others mate a pair of letters with a pair of phonemes (e.g., initial *wh* is pronounced /hw/, as Samuel Orton so beautifully parodied in naming his summer home *Hwimsy*). Most of the rules are context-dependent: for example, *ch* is pronounced /k/ after initial *s* (where in most other contexts it is pronounced /č/; and *x* is pronounced /z/ in initial position, but /ks/ or /gz/ elsewhere. Finally the rules are generally ordered, like these latter ones: the machine tries one alternative first, and if this does not apply, it applies the second.

Hunnicutt's 577 rules include many relatively obscure rules, that is, rules which are only rarely employed, like the rule for pronouncing *nch* in *anchor* as opposed to *lunch.* The reading machine can get by with half that number, if the user is willing to tolerate a few more mispronunciations. In fact, the number can be cut in half with only a 10 percent increase in errors. But even the full 577 leads to the mispronunciation of many of the most common words in English, like *one* and *have* and *of.*

The fact that there are so many apparent irregularities has, over the years, led more than one reading expert to suggest that it is unwise, if not useless, to try to teach the child the cipher, and to argue that we should not emphasize decoding in reading instruction.

Moreover, the critics of decoding will say, there is serious doubt about whether these rules are used by skilled adult readers in ordinary reading (e.g., Goodman 1967; F. Smith 1971).

Instead, they say, the fluent reader makes use of all kinds of information — syntactic, semantic, and pragmatic — in recognizing the printed word in context, and we should try to teach the beginning reader to read in the same way.

We cannot accept this argument. The argument that English spelling is frequently irregular overlooks the fact that the irregularities are not arbitrary: we do not pronounce *one* /kæt/ or *of* /spən/. Most of the mispronunciations produced by Allen's reading machine are easily recognizable, even in isolation (like /ɛgzhɔst/ for *exhaust*, and /skɨzofrɛnɨc/ for *schizophrenic*), and many others (like /ijr/ for *eager*) are easily detected and corrected in context.

The question of whether skilled adults do (or do not) make use of the orthographic cipher in fluent reading has not been settled to our satisfaction (Gough and Cosky 1977). But we believe that whatever the adult reader finally does, the beginning reader of English has no choice in the matter; he *must* internalize these rules.

The reason is that he cannot do anything else, and hope to read. Think of this: the child who has worked through a basal reader has been exposed to 500 or 600 words. But his speaking vocabulary is already more than ten times that number, and by the time he reaches college, it has been estimated, he will recognize 50,000 words or more (Oldfield 1963). We have already argued that the difficulty of learning a sight word increases with each additional item. It defies imagination to suppose that the child could learn 50,000 items as arbitrary associations. (Remember that the reader of Chinese characters or Japanese kanji is considered quite accomplished if he knows as many as 2,000.)

But whether or not the child could accomplish such an extraordinary feat, there is a more important consideration: he could not memorize them until he had been exposed to them. If we credit the entering college student with the ability to read even 25,000 different words, then between his basal reader and his first college textbook, he must have once encountered each of these words for the first time. So before he enters college, the reader must encounter nearly 25,000 *absolutely novel* printed words. That is, he must face in print more than 25,000 words which he has never seen in print before. His only hope of recognizing these words is to convert them into their spoken form, and hope that this form is familiar.

It might be objected that context would enable the child to read these words. We reply that it could not. The role of context in reading is, we believe, seriously exaggerated by most scholars (cf. Gough, Alford, and Holley-Wilcox 1979). By our estimates, context will enable the reader to predict, at best, no more than one word in four. Moreover, the predictability of a word in context is correlated with its frequency (Alford 1980). The words which are predictable will tend to be those words which the child already recognizes, and the novel words which he now must recognize are exactly the ones which context will *not* enable him to predict.

We conclude, then, that if the child is to become a fluent reader, he *must* learn to decode, more precisely, to decipher. He must internalize the orthographic cipher of English.

But if this is the case, then the child is confronted with a serious problem, for there is no way we can give him that cipher. There is no way we can inform him that these letters go with those phonemes. In phonics, we try. We tell him that *b* is pronounced /bə/ and that *sh* is pronounced /š/ and that a final *e* following a vowel and consonant tells you to say the long form of the vowel before the consonant. But we believe that the rules of phonics bear only a superficial resemblance to the rules which the fluent reader has internalized.

For one thing, what phonics does is pair each letter or letters, not with a phoneme, but with a syllable; *b* is pronounced /ba/, *t* is pronounced /ta/, and *a* /æ/. Many phonemes (especially the stop consonants) cannot be produced in isolation; all the rest take a different form, at least phonetically, when produced in isolation (as in the rules of phonics) than when they are combined with others in words. For example, we tell the child that *t* is pronounced /tə/; but the *t* in train is pronounced /č/ by many of us (Read 1971). For another thing, the rules of phonics are conscious and explicit — we state them in English — while the rules which the reader uses are unconscious and implicit. Most fluent readers will pronounce *cile* /sail/ and *cale* /kel/ without even noticing that they pronounced *c* as /s/ in the first item but /k/ in the other. Finally, the implicit cipher is too fast for phonics: it takes a fluent reader only about 20 msec. longer to read aloud a pseudoword like *feal* (which he has never seen before) than to read aloud the most familiar words in his reading vocabulary (Theios and Muse 1977). He could not be doing this by consulting the rule that when two vowels go walking the first does the talking.

The Elements of Cryptanalysis

Here, then, is the crux of the child's problem as he enters the second stage of reading acquisition: he must acquire the orthographic cipher, but he cannot get it from his teacher. There is only one thing for him to do, and that is to break the code. We propose, then, that this cryptanalysis constitutes the second stage of reading acquisition, and that the difficulty of this cryptanalytic feat is the major stumbling block in the course of reading acquisition.

Consider what must go into a successful cryptanalysis. First, and foremost, the cryptanalyst must have sufficient data. He must have a

sufficient number of ciphertext-plaintext pairs for him to detect regularities, for him to separate systematic correspondences from accidental ones. Second, he must recognize the alphabet of the ciphertext; he must be able to recognize the elements of which the ciphertext messages are formed, i.e., the letters of the printed word. Third, he must recognize the alphabet of the plaintext; he must recognize the phonemes of which spoken words are formed. Finally, he must recognize that he is confronted with the cryptanalytic problem, and he must try to solve it. Each of these conditions must be met for the child to solve the problem; there is reason to believe that none of them are naturally available to the child.

Take first the matter of cryptanalytic intent. What we mean here is that the child must recognize that the printed message is an encoded version of a spoken one, and make an effort to figure out how the spoken message is enciphered. We adults take it for granted that the spoken language can be written down, and that a printed text must correspond to a spoken one. It seems natural, then, to suppose that the child must also appreciate this fact.

But notice that this is not at all an inevitable consequence of human nature, for if it were, then every language would have a written form. To see that this is false we need only remember that there is a school of linguistics which was founded to train missionaries in phonetic transcription in order for them to render the Bible into as yet unwritten languages. There is no reason to think that the child will come to the realization that print is language written down unless he is told so, in one way or another.

When you stop and think about it, it is not obvious what would lead the child to this insight. We are inclined to think that it is probably the experience of watching an adult read aloud, of catching on to the fact that what the adult says is somehow dependent upon those marks on the page in front of him. Or it might be the experience of having an adult say "*That* says X" under circumstances where it is clear what *That* is. But such experiences are certainly not inevitable; not every child is read to, and even for those that are, there are many other possible interpretations of the adult's behavior. The interviews with young children conducted by Reid (1966) and Downing (1970) are interesting in this regard. They suggest that even among children who have listened to adults read there are misconceptions: some children think that reading is just talking with a book in one's hands. The nature of the writing system and the nature of reading are not naturally available to the child. These things must be explained to him, or he must figure it out for himself. Lacking that understanding he can have no idea of what he is supposed to do, and there is no reason why he should decipher the orthography.

Next, consider the matter of the ciphertext. It should be obvious that if the child is to learn that this letter or sequence of letters corresponds to that phoneme or sequence of phonemes, he must first recognize that the ciphertext *contains* letters. That is, he can no longer treat the printed word as an arbitrary collection of lines and curves, a collection which can be sampled at random; instead he must recognize that the ciphertext is to be treated as a string of symbols, a sequence of characters. In short, he must appreciate the fact that the ciphertext is composed of an alphabet.

We take this so much for granted that it is hard to appreciate that it is not part of our nature; it is hard to remember that we had to learn to see print in this way. But up to this point, nothing has forced the child to study, to look at, even to notice, the letters which form a word, to say nothing of their order. But now he must notice just these things. He must note each and every letter of each word, and its location in the word, for only in this way can he hope to pair off the elements of the plaintext with those in the ciphertext. And please note that this is not a natural thing for the child to do. We confess that we cannot think of another instance in the child's experience where the child must recognize some visual stimulus as composed of a particular configuration of commutable, permutable, elements. (This is not true of faces, or houses, or animals, or anything else we can think of.)

Moreover, the elements themselves make use of what is apparently an unnatural feature for the recognition of objects, one stressed by Samuel Orton half a century ago — orientation. Thanks to Shankweiler and Liberman (1972), we now know that the confusion of left and right (as *b* with *d*, or *p* with *q*) is not the central problem it was once thought to be. Such confusions account for only a fraction of the errors of any reader, and few (if any) readers seem to make such errors consistently. But every beginning reader is confronted with the problem of learning that orientation is relevant, not just with respect to how you approach an object but with respect to the very identity of the object. (Note that children never fail to respect orientation in this regard; the child never reaches for the doorknob on the left when it is on the right, or goes to his right to pick up a toy which is on his left.) Everything in the child's prior experience (and, indeed, our own) suggests that an object and its mirror image are one and the same object. To learn to call one thing a *b* and its mirror image a *d* is, on the face of it, unnatural. But the child who would learn to read English must learn to respect this distinction. Whether recognition of individual letters causes difficulty or not, the recognition that each ciphertext word is composed of a sequence of meaningless elements must be hard for the child to achieve. The requirement that he note the same fact about the plaintext, that he recognize

that each spoken word is composed of a sequence of meaningless elements, may be even more unnatural.

The child of 5 or 6 has little problem with the fact that the spoken language is composed of *words*, and we can imagine why this should be so. Words are meaningful. The child encounters many words in isolation, and he is frequently asked to deal with them in this way. So it is little wonder that when he first tries to learn to read, he tries to deal with words, and he treats the written language as if it were a code matching a unique symbol with each spoken word. But evidence has emerged, over the past decade, that he has great difficulty in recognizing that spoken words are, in turn, composed of phonemes, and that these are the things which English orthography intends to record.

To us literates, it is obvious that words are composed of phonemes (even if we don't call them that), and we had no reason to doubt that the child knows this as well. After all, we know that the child must distinguish one spoken word from another on the basis of its phonemes (he can tell /bæt/ from /kæt/ on the basis of a single phoneme). But what we have recently learned is that to say that the child can tell one word from another, or produce one word as opposed to another, on the basis of a single phonemic contrast, is not to say that he realizes that each word is composed of a sequence of phonemes. Evidence is growing that our facile assumption, that the average five or six-year old child is aware of the phonemes which constitute a spoken word, is false.

Consider this: one would suppose that anyone who could decompose a word into its constituent phonemes could decide whether two words begin with the same phoneme, or whether a given word begins with a given phoneme. But Calfee, Chapman, and Venezky (1972) have shown that kindergarteners perform at chance on such tasks.

Or consider this point: one would suppose that anyone who could decompose a word into its constituent phonemes could decide whether two words end with the same sequence of phonemes. In other words, he could decide whether two words rhyme. Again, Calfee et al. (1972) have reported that kindergarteners cannot accurately judge whether two words rhyme.

Or consider a third: one would suppose that anyone who could decompose a word into its constituent phonemes could tell you how many phonemes it contained (given that they could count sounds). So, for example, a child taught to rap once for *e*, twice for *go*, and thrice for *dog* should easily learn to tap once for each phoneme in a word. But Liberman (1973) has shown that four-year-olds cannot do this, nor can 80 percent of five-year-olds.

Or consider this fourth point: one would suppose that anyone who could decompose a word into its constituent phonemes could learn to rearrange those phonemes. For example, he could learn to move the first one to the end of the word, and add a redundant diphthong: he could learn to say *atbay* instead of *bat*, or *igpay* instead of *pig*; he could learn pig Latin. But Savin (1972) has reported that disabled readers cannot master this supposedly childish game.

Finally consider this: one would suppose that it would be child's play for anyone who could decompose a word into its constituent phonemes to simply drop one of those phonemes and then pronounce what was left. So if we asked you to tell us what would be left if we removed the *r* from *crop*, we would expect you to have little difficulty. But Bruce (1964) has found that children with mental ages of less than six are simply unable to do this.

A variety of evidence thus indicates that the child confronted with the cryptanalytic task may not yet possess the essential ability to recognize the elements of the plaintext, that is, to decompose the spoken word into its constituent phonemes. We think that this may yet prove to be the most important stumbling block in the path to reading yet discovered. But we do not yet know whether it is predictive or not. That is, we do not know the extent to which prior possession of this insight will facilitate learning to read. All we know for sure is that the two must go hand in hand: he who would perform the essential cryptanalysis must either have or acquire this metalinguistic insight. It certainly seems likely that prior training in metaphonological awareness would facilitate reading acquisition, but that remains to be seen.

We have suggested that cryptanalytic intent, awareness of letters and their order, and metaphonological awareness are essential ingredients in reading acquisition. There remains one final factor suggested by the cryptanalytic notion, and it is a critical one: the pairing of plaintext and ciphertext messages. On the cryptanalytic view these four factors are intertwined; all four are necessary for success, and the absence of any one will result in the child's failure. For example, if the child cannot segment the spoken word into its constituent phonemes, the best intentions, the keenest attention to the printed word, and an abundance of cipher-plaintext pairs will not enable the child to read.

Most of these necessities are recognized by one or another methods of reading acquisition, and especially by theorists. But the final ingredient required by the cryptanalytic hypothesis is often overlooked: it is the necessity for having adequate data, a sufficient number of ciphertext-plaintext pairs.

For the child to break the code, to discover the cipher, he must be given a sufficient number of pairs of messages, one in ciphertext, the other in plaintext, for him to discover the correspondences betwen the two. No matter how good his intuition, no matter how carefully he studies the printed word, no matter how serious his intent, he cannot work out the cipher without sufficient data.

We suppose that the child discovers that the letter *v* goes with the phoneme /v/ by observing that the two vary together: when the letter *v* appears in ciphertext the phoneme /v/ is heard in plaintext, and when *v* goes, so does /v/. Covariation is most conspicuous when one letter or digraph changes along with one phoneme while all else remains constant, as in *cat-hat-mat-rat*, or *bat-bet-bit-but* or *fish-fin-fit-fix*; or when one letter and one phoneme remain constant while all else changes, as in *cat-cup-coat-cry*. Thus we expect that the so-called linguistic method (cf. Bloomfield and Barnhart 1963) should be an efficient way to facilitate the child's cryptanalysis. But our assumption is only that he needs sufficient data to observe covariation.

We are intrigued with the conjecture that the only pairs which contribute to the cryptanalysis are those pairs which the child has committed to memory, that it is the corpus of materials learned in the paired-associate stage that serve as data for the cryptanalysis. But we are only committed to the view that the child must be exposed, in one way or another, to enough printed word-spoken pairs to extract the necessary correspondences.

Let us be very explicit on this point. What we are saying is that we believe that the crucial learning event occurs when the child perceives (or thinks of) a printed word at the same time he perceives (or thinks of) its spoken counterpart. This is the important experience in the decoding process, and the more such experiences the child has, the better.

It is in this connection that we would praise phonics. As we have said, we do not believe that phonics teaches the child the rules of the cipher which he must master. But it does provide the child a virtually indispensable tool for collecting data on his own, for discovering what spoken word goes with an unfamiliar written word. Thus the application of the rules of phonics to sound out a given word gives the child an additional datum: here is the spoken word that goes with that printed one.

We would note, though, that in our view, phonics is *theoretically* dispensable. It gives the child artificial rules by which to get the data he needs to learn the real rules. If there were some other way for him to learn the spoken identity of a printed word he does not recognize, this would serve just as well.

In this connection, we find the historical practice of beginning reading instruction with materials the child knows by heart, like the Lord's Prayer or biblical passages of the Hornbook, intriguing. What this does, of course, is enable the child to produce the necessary spoken words, and he can study the pairings of these words with their printed forms at his leisure.

The danger, of course, is that he will not. When one of our children came home from school with her first reader to demonstrate her ability to read it, it became clear that she had "only" memorized it; she simply recited it while turning the pages. This was a marvelous cognitive achievement, but it was not reading. It was necessary to use flash cards to teach her to really read the book. But Carol Chomsky (1976) has reported considerable success in helping backward readers by urging them to read along with a cassette recording of a target story, and we believe that methods like this are worth pursuing.

We suggest that any method which provides the child with adequate data, with pairs of printed and spoken words which adequately present the correspondences between them, will enable the child to read, provided that he has the proper intent, that he recognizes the letters of the printed words and their order, and that he can segment the spoken word into its constituent phonemes. But in the absence of sufficient data, the cryptanalysis cannot succeed.

Summary and Conclusions

Let us recapitulate our argument: first, we posit that learning to read begins with the child forming arbitrary associations between selected aspects of printed words and their spoken counterparts, that this makes each additional word increasingly difficult to acquire, and that this natural selectional strategy will eventually break down amid error and confusion. To restore order, the child must then recognize that the pairings of printed words with their familiar spoken forms are not arbitrary, but are instead related by a complex cipher. To learn to read, he must break this cipher. To succeed in this, he must confront the cryptanalysis; he must recognize the basic units of the ciphertext (i.e., the letters which form a word); he must recognize the basic units of the plaintext (i.e., he must be able to decompose a spoken word into its phonemes); and he must find sufficient data for him to unravel the correspondences between the two. None of this is natural, but if he succeeds he will read.

It must be obvious that if war should break out between those, in Chall's terms, who emphasize the code and those who emphasize meaning in

reading instruction, we would enlist under the banner of code. But let no one say that we claim that decoding is all there is to reading. Some years ago, one of us (Gough 1972) tried to detail the events which he supposed might transpire in the brain of the reader in as little as one second of reading. To do so, it was necessary to posit no fewer than seven different processes, and decoding was only one of them. Reading *clearly* involves much more than decoding. But we submit that any child who can speak and understand the language has already mastered all but one of the component processes: what he does not have is the ability to decode. Give him that, and he will read.

There are those who would dispute this. There have always been some such, at least since students of reading became self-conscious in the middle of the last century. In a delightful passage written over a century ago, Russell and Goldsbury (1845) described a fictitious ninny named Memorus Wordwell who could decode anything in sight, but could understand nothing he read.

We have never seen such a reader, and we do not expect to see one (though, as Thornton Burgess said of the purple cow, we'd rather see than be one). But if we ever do see one, we expect to see that he cannot understand a spoken sentence either.

Our view of reading, that it consists of decoding plus linguistic comprehension, may be too simple. If so, it should be easy to refute, for it holds that any child with normal comprehension who learns to decode with facility will know how to read, and if any child with normal comprehension fails to read, it is because he has not learned to decode with facility. In our view, the complex requirements of the cryptanalysis necessary for decoding are sufficient to explain why reading is simply an unnatural act.

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